Space Weather Technical Forecast

Issued on Thursday, 16 February 2023 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares (R1/R2 Radio Blackouts) likely. G1-G2 Minor/Moderate Storms likely, mainly day 2, due to CME arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with two low-level M-class flares, one from AR3213 just over the northwest limb, and another from a new region rotating onto the disc from over the northeast limb. AR3214 is also no longer visible, but still has the potential to produce visible flares. AR3226 Ehi/Beta-Gamma-Delta dominates the northern centre disc, but besides a small delta spot in its broken trailer region, it has a relatively simple bipolar magnetic structure. Including the new region rotating onto the disc, there are six visible sunspot regions, however all other regions are magnetically simpler.

Two filament eruptions occurred, including one from the southwest disc around 15/2350 UTC, and another from the northwest disc 16/1020 UTC, associated with a long period C9 Hyder flare. The CMEs that these produced are both likely showing on the most recent SOHO LASCO coronagraph images, however these have yet to be confirmed or analysed for any Earth-directed component.

Solar Wind / Geomagnetic Activity: The solar wind environment was indicative of a transition from the tail end of a CME which arrived on the 14th, into the CIR ahead of a fast wind environment, likely from an obscured coronal hole in the northern solar hemisphere. The observed speed at L1 was initially at around 300-330 km/s, but started erratically rising from 16/0000 UTC, to reach 440-470 km/s by 16/1200 UTC. Density was around to above average, with a period of 20-30 ppcc from 16/0000-0400 UTC. Total IMF, Bt, was initially Moderate at around 10-12 nT with the Bz component persistently negative (southward) reaching -11 nT at 15/1924 UTC before rotating to a positive (northward) direction at 10-14 nT. The phi angle through this period was neutral. The total IMF then increased after 16/0000 UTC to be strong by 16/0400 UTC, ranging 15-23 nT thereafter. This including a three distinct rotations between positive and negative Bz values, falling to a peak southward value of -20 nT. Despite this IMF rotation in the north-south direction, the phi angle became persistently positive (away from the Sun). Geomagnetic activity has been Unsettled to Active, with one G1/Minor Storm interval between 16/0600-0900 UTC (Kp 3-5).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 has been at background levels throughout. The associated 24 hour electron fluence has been below the Active (1e8 integrated pfu) threshold throughout, with 1.31e6 integrated pfu observed at 16/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to Low activity expected with further M-class flares likely. AR3226, along with AR3214 and AR3213 over the northwest limb and the new region on the northwest limb are the most likely source regions for any significant activity.

Solar Wind / Geomagnetic Activity: A filament eruption CME, which left just east of the centre-southern disc on the 15th is forecast to arrive 17/1800 UTC +/- 12 hours. Otherwise current fast winds, likely from an obscured coronal hole feature in the northeast disc are expected to continue

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day 1 (16th), perhaps briefly easing before the CME arrival day 2 (17th). Ongoing CME influence is then expected day 3 (18th) before solar winds ease by day 4 (19th). Unsettled to Active geomagnetic activity day 1 (16th) and early day 2 (17th) with an ongoing likelihood of G1/Minor Storms. CME arrival day 2 is then expected to bring Active to G1/Minor Storms and a chance of G2/Moderate storms. These easing day 3 (18th) but still a chance of isolated G1/Minor Storms). Becoming mainly Quiet, with isolated Unsettled spells day 4 (19th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of exceeding S1 in response to any significant flares. High energy (greater than 2 MeV) electron flux has the potential to climb through the period due to the recent enhanced solar wind environment, however the CME arrival expected later day 2 (17th) results in a very low confidence forecast. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing chance of rising above later in the period.

Figure 1a. Observed L1 Solar winds

Figure 1b. BGS Estimated Kp

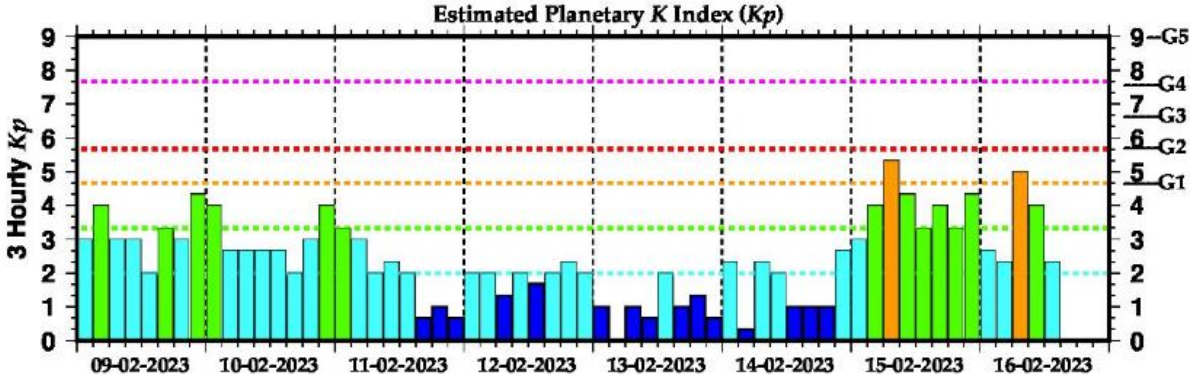

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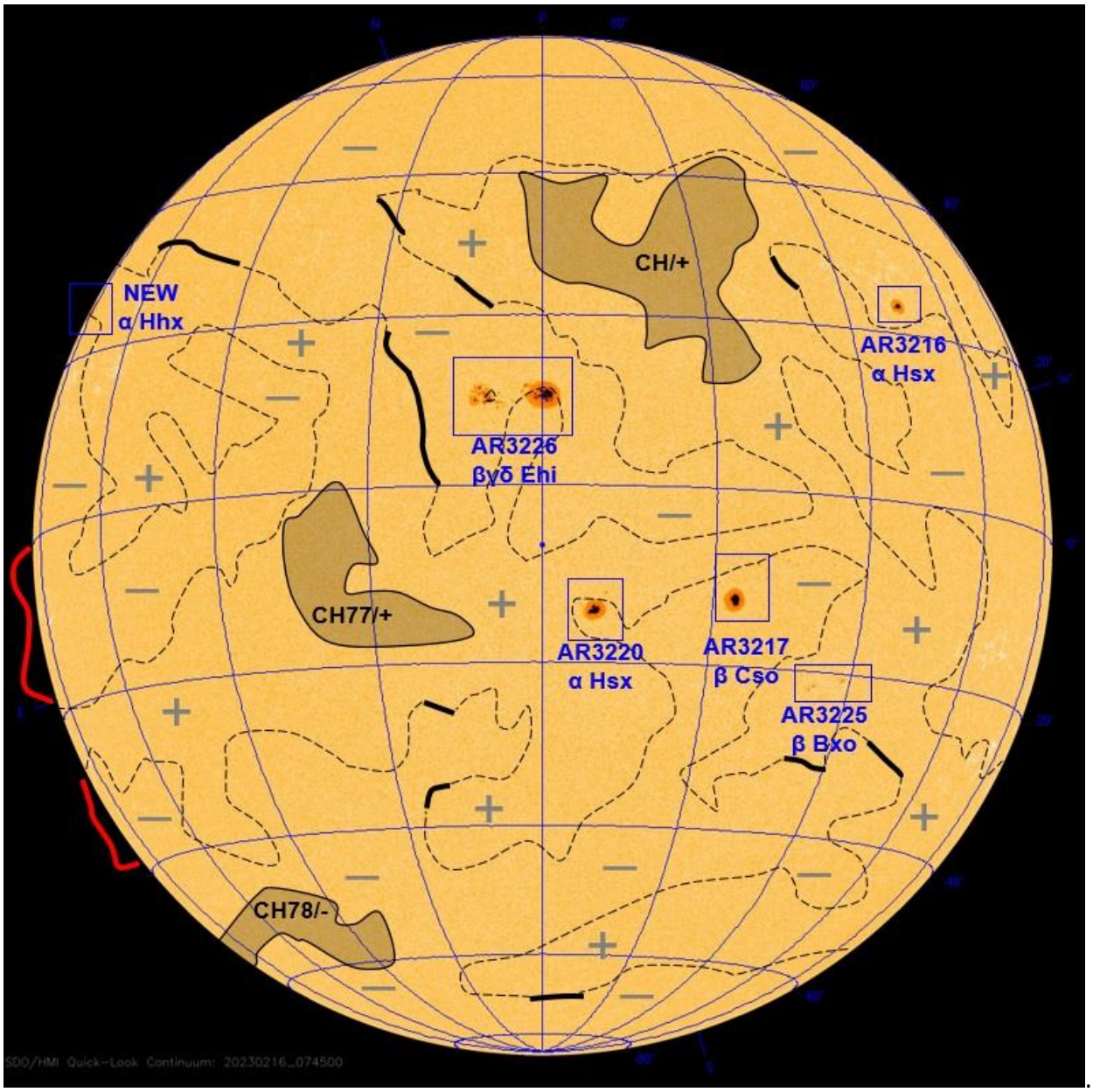
Figure 1c. Solar Analysis Valid 16/08000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME produced by a filament eruption in the vicinity of AR3220 early on 15th has been assessed as likely Earth-directed with an expected arrival on the day 2 (17th), at 17/1800 +/- 12 hours. Further CMEs on the 16th have yet to be assessed.

Earth is currently under the effect of the fast wind, likely originating from an obscured coronal hole positioned to the north of the magnetic looping of AR3226. This enhancement has been capture by enlil, with solar winds expected to peak around 500-600 km/s by day 2 (17th). This will then be followed by a CME arrival at some point later day 2. Ongoing CME effects are then expected day 3 (18th), before easing day 4 (19th).

Unsettled to Active geomagnetic activity is forecast day 1 (16th) and early day 2 (17th) with a likelihood of G1/Minor Storms due to elevated solar winds. CME arrival day 2 is then expected to bring Active to G1/Minor Storm intervals and a chance of G2/Moderate storms. These conditions gradually easing day 3 (18th) but still a chance of isolated G1/Minor Storms). Becoming mainly Quiet, with isolated Unsettled spells day 4 (19th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	50	60	30	5
Strong	G3	No	1	10	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0815 UTC	Partial	Filament	12E 10S	650 km/s	17/1800 UTC +/- 12hrs	Moderate confidence.

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Figure 2a: Enlil and Ensemble – Current enhancement visible, along with CME arrival

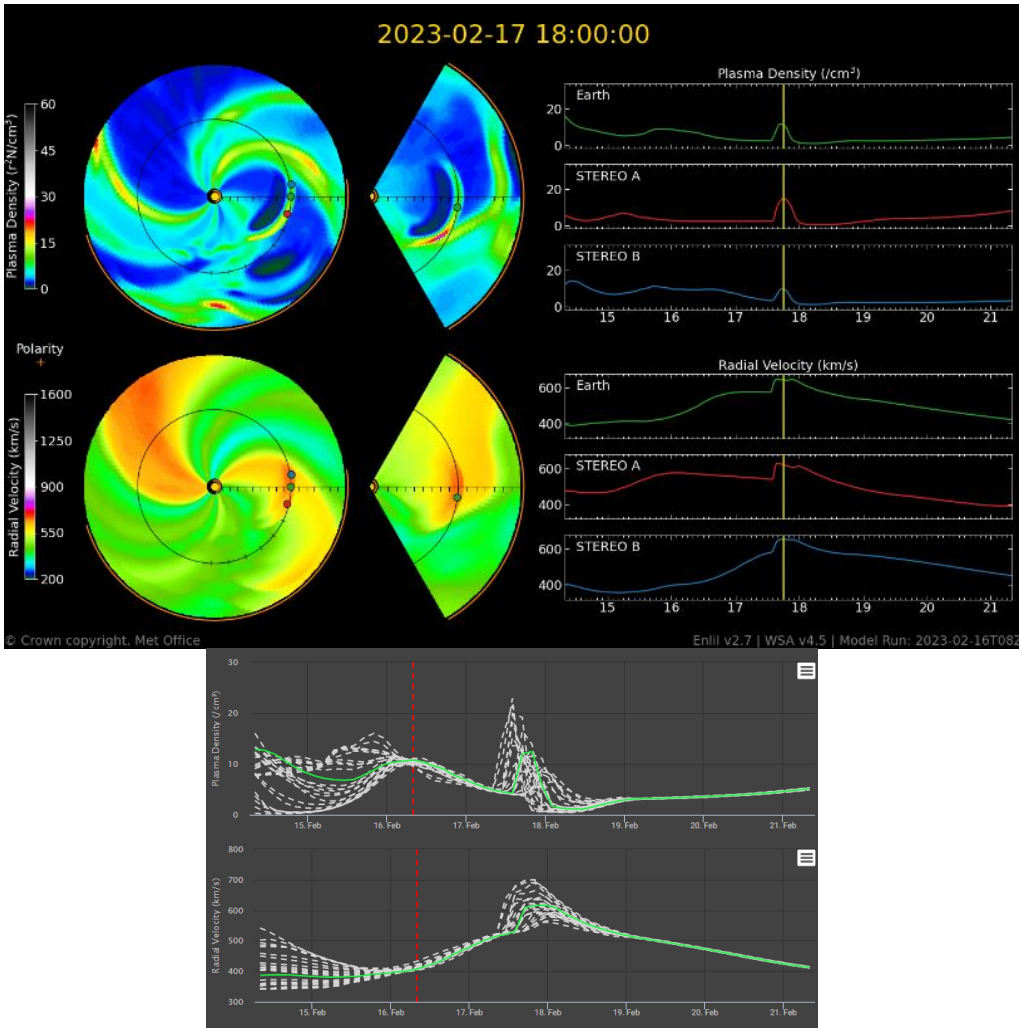
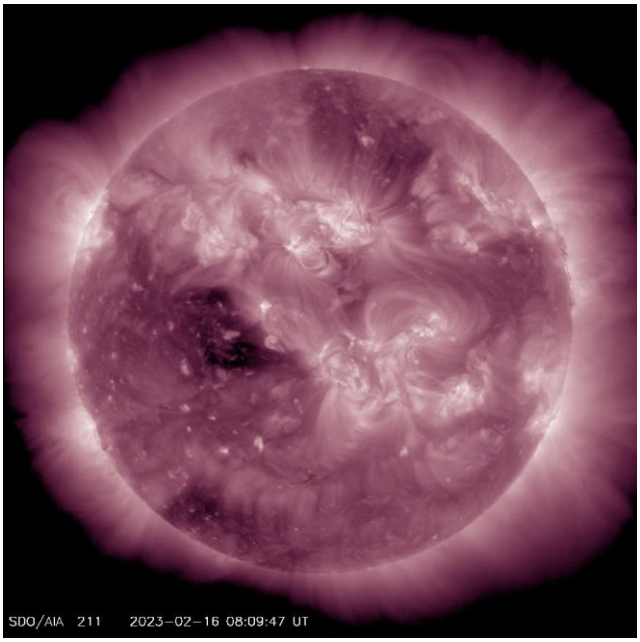


Figure 2b: SDO aia-211 with obscured CH in north disc.



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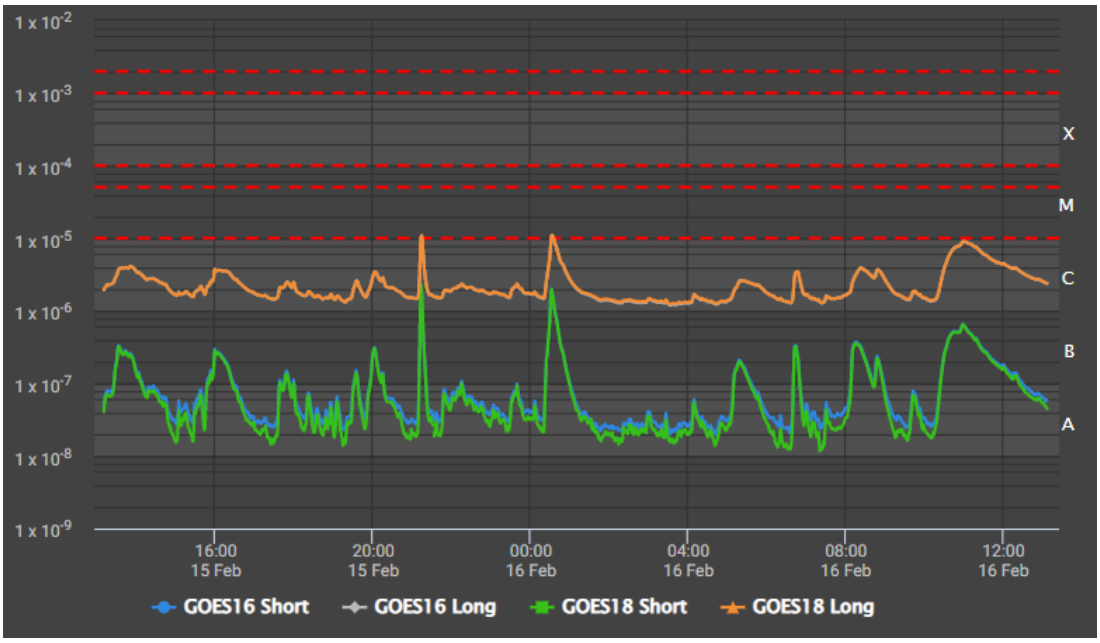
Radio Blackouts - X-Ray Flares:

Activity is expected to be Moderate to Low, with an ongoing likelihood of M-flares, primarily from AR3213, AR3214, AR3226 or perhaps the new region moving onto the northeast disc.

AR3226 Ehi/Beta-gamma-delta dominates the northern central disc with a large symmetric leader followed by a more ragged and broken trailer. Despite its moderate size, has a mostly simple magnetic structure with a north-south inversion line. There is a very small delta spot, however, located amongst the broken structure of the main trailer, leading to some increased potential instability of this region. AR3213 and AR3214 are now over the northwest horizon, however flare activity from these regions will potentially remain visible from the Earth-side, at least on day 1 (16th). The new region in the northwest remains very difficult to assess, however it has produced an M1 flare as it rotated onto the disc and maintains some visible looping on SDO imagery, suggesting further M-flares are possible from this region.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	55	50	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



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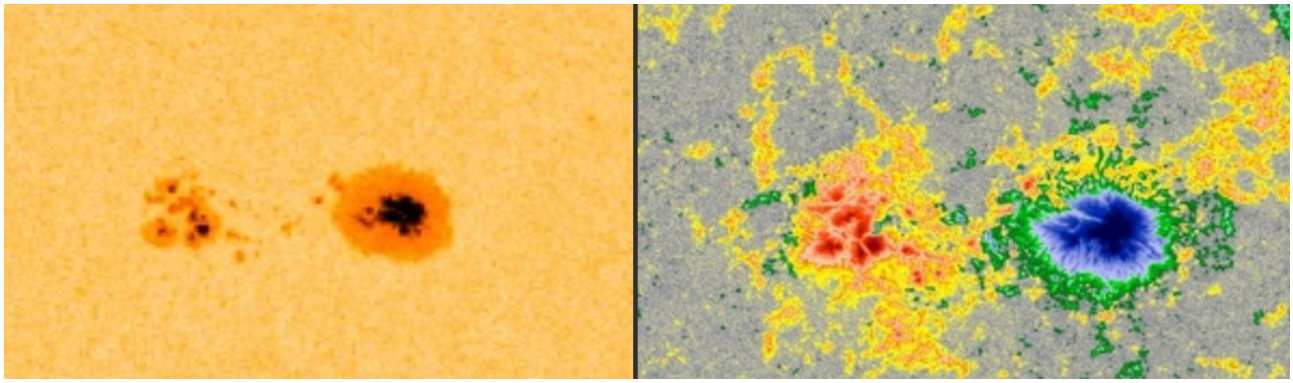
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels.

No notable high energy proton response has been observed from recent M-flares. Any further significant flares may increase count rates, with a slight chance of exceeding the S1 level. The main risk is from AR3213 and AR3214 which have now rotated over the northwestern horizon, but may still give Earth-directed protons on day 1 (16th). Any significant flaring from AR3226 also includes the potential to increase count rates.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO hmi intensitygram and magnetogram of AR3226 in centre disc



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed by GOES16 has been at background levels. The recent solar wind enhancement has likely resulted in an increased electron flux in the outer Van Allen Belt, however this may be short-lived, with a CME arrival forecast on day 2 (17th). This results in a very low confidence electron forecast.

Initially background flux has the potential to become Moderate, perhaps briefly High into day 2 (17th), before likely dropping out due to the CME arrival. A recovery in flux is then possible day 3 (18th) onward, with a chance of returning to High levels later in the period. The associated 24 hour electron fluence is expected to remain below the Active threshold (1e8 integrated pfu) throughout, however the increased uncertainty with the flux forecast gives a slight chance of Active fluence, mainly day 3 (18th) onward. REFM doesn't capture the currently enhanced solar wind environment or the expected CME arrival on the 17th, so should only be used cautiously.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	20	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron Flux and associated 24 hr fluence with REFM

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